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## FLUORESCENCE OF MINERALS

The behavior of some minerals in ultraviolet light furnishes a quick and useful method of finding and roughly identifying them. In recent years this method has been widely used in prospecting for tungsten ore in which the metal occurs in the mineral scheelite. In ordinary light scheelite is inconspicuous and easily overlooked, but in ultraviolet light it glows with a beautiful fluorescence.

Fluorescence of a substance is the result of a conversion of invisible ultraviolet light to visible light. It is generally believed that the molecular structure of the substance plays an important part in the conversion; however, in many instances the phenomenon is apparently due to the presence of impurities, or activators. Iron, cobalt, nickel, copper, zinc, manganese, silver, tin, rubidium, antimony, thallium, lead, bismuth, uranium, and samarium are common activators. It should be emphasized that one or more of these elements need be present only in extremely small percentages in order to cause fluorescence in some minerals which would otherwise not fluoresce. The action of activators is not completely understood. For instance, primary uranium minerals, such as pitchblende and carnotite, do not fluoresce, whereas most of the secondary uranium minerals fluoresce yellow green.

Most substances which fluoresce do so only as long as they are exposed to the required stimulating energy. However, a few substances continue to fluoresce for periods ranging from several seconds to hours, depending on the material, after the stimulating energy is shut off. This phenomenon is known as phosphorescence. It should be noted that specimens must be examined with ultraviolet light in total darkness in order that maximum fluorescent and phosphorescent effects may be observed.

Studies have shown that the fluorescent color of a mineral may vary with the kind and quantity of trace elements, or activators, and also with the particular wave length of ultraviolet energy used. The wave length used is dependent upon the type of generating equipment used and on the filter employed to remove visible light. Utilization of fluorescence of minerals has advanced with the development of various convenient sources of ultraviolet energy, some of which are now available at reasonable cost. However, ultraviolet units differ in the wave lengths they produce. This factor, as well as the fact that there are variations peculiar to particular minerals, is not always fully appreciated or understood. Thus some of the contradictory claims as to fluorescence of minerals are not surprising.

Light rays are energy, and can conveniently be considered as a form of wave motion. The properties of light, such as color as seen by the eye, vary with wave length. The eye, however, is limited in what it can see, red being the longest and violet the shortest wave lengths that are visible. Wave lengths slightly longer than red are termed infrared or heat rays, and those slightly shorter than violet are the ultraviolet rays.

A common unit of measure of wave length is the Angstrom unit (here abbreviated AU), one ten-millionth of a millimeter. The visible spectrum ranges from about 8000 AU maximum for red to 4000 AU minimum for violet. The ultraviolet rays are a continuous series from about 4000 to 100 AU, merging at the short end of the series with X-rays.

Differences in wave length of ultraviolet energy may or may not produce contrasting fluorescent colors in various minerals. Scheelite does not respond to long wave-length ultraviolet energy, but it fluoresces conspicuously on exposure to shorter wave lengths. Thus, before the significance of an observed fluorescent color of a mineral can be fully appraised it is essential to know at least approximately the wave length of the ultraviolet energy that produced the fluorescence.

The nature of the ultraviolet radiations available to the average person, who does not have access to the special equipment necessary to isolate specific wave lengths, consists of two differing though overlapping regions of the ultraviolet spectrum. One range of wave lengths is from 3100 to 4000 AU, but with 3650 AU predominating; the other range is from about 2300 to 4000 AU, with 2537 AU predominating.

The longer range of wave lengths, 3100 to 4000 AU, is obtained from incandescent filament globes and various mercury units that operate at moderate to high pressures and at relatively high temperatures. The common glass ordinarily used screens out wave lengths under 3200 AU, and even when special glass is used the heat-resisting filters necessary to remove visible light also removes wave lengths of 3100 AU and less.

The second type of radiations is obtained from the cold quartz tube which utilizes ionization of mercury vapor at low pressures and temperatures to produce ultraviolet light, 60 to 90 percent of which is in the vicinity of 2537 AU. This tube has two outstanding advantages in addition to the relatively large quantity of ultraviolet energy in the shorter wave-length range that it produces. First, the tube consumes very little electric energy, so that with a suitable transformer it is practical to operate small portable units from standard dry cell batteries. Second, in the absence of even moderate heat, a non-heat-resisting filter can be used which transmits the shorter wave lengths with high efficiency. Generally speaking, the moderately priced portable units used by prospectors are of the cold quartz tube type.

Those who use ultraviolet light for prospecting or mineral identification should note that mineral species from one locality may fluoresce, whereas apparently identical ones from another locality may not. Also, several specimens of a mineral from the same or different localities may fluoresce different colors. For instance, pure willemite (zinc silicate) does not fluoresce. However with the presence of 1 to 5 percent manganese as an impurity this mineral shows bright green fluorescence under both long and short wave-length ultraviolet light. Scheelite is commonly associated with deposits of limestone which are composed predominantly of the mineral calcite (calcium carbonate). Not all calcite is fluorescent, but